A Method for the Comparative Study of the Human Skull, and its Application to Homo sapiens *and* Homo neandertalensis.

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In a previous study of the Gibraltar skull I was so deeply impressed by the impossibility of discovering any fixed points of reference that I proposed to regard the comparison of cranial outlines, especially of the so-called sagittal sections, as a purely geometrical problem. A recent application of this method thus suggested has revealed some facts which appear to be of sufficient interest to justify a short note as a preliminary to more detailed exposition.

Confining our attention for the present to a sagittal section we begin by determining its centre of figure or (what is the same thing) its centre of gravity;* a diameter is then obtained by drawing through the centre a line which bisects the angle formed by two radii drawn to the basion and opisthion respectively. A second diameter is drawn at right angles to the first and in this way the section is divided into four quadrants, a frontal, parietal, occipital and facial quadrant. The semi-diameters or radii cut the periphery in the vicinity of the nasion (ν), bregma (β), lambda (λ) and the middle of the occipital foramen, and thus we may term the points of intersection the nasion (N), bregma (B), lambda (L) and foraminal (F) poles. The position of any anatomical point on the periphery may then be indicated by the length of the radius meeting it and its angular distance from the nearest pole, the angle being regarded as positive or negative according as it lies right or left of the pole counting counter-clockwise (fig. 1).

In skulls belonging to the species *Homo sapiens* the nasion angle is always comparatively small; thus fifteen skulls of Australian aborigines give an average value of $+0{\cdot}8$, with a range of -6° to $+7^\circ$; eight negro skulls from various localities give an average of $+1{\cdot}5^\circ$ and a range of -2° to $+5{\cdot}5^\circ$; and single skulls of various races seem to show that these limits are rarely exceeded, thus in a typical skull of a Swede given by Retzius to Acland the angle is $+2^\circ$, in a Swiss -2°, Eskimo $-2\frac{1}{2}^\circ$, Veddah $+3^\circ$, Gond $+3^\circ$, Bushman -3°; two Tasmanian skulls give respectively $+2^\circ$ and $-1{\cdot}5^\circ$, two English $-1\frac{1}{2}^\circ$ and $+3^\circ$. The skull of the "Old man of Cro Magnon," so far as can be asserted from a cast, has a nasion angle of

* The section which is closed by a line drawn from the nasion to the basion is traced on thin Bristol board and the figure then cut out. Its centre of gravity is obtained by the well-known method of suspension.

$+4{\cdot}5^\circ$ and thus accords, in this as in other characters, with the existing species. The exceptionally high value of $+8\frac{1}{2}^\circ$ was observed in the skull of a Finn.

In *Homo neandertalensis,* on the other hand, the angle is much larger and is never, so far as we know, positive. From the excellent cast of the skull of La Chapelle-aux-Saints, provided by my friend, Prof. Boule, I find a value of -17° for the nasion angle, and a cast of the Gibraltar skull as restored by Prof. MacGregor gives -10°. The occipital foramen of the Spy skulls is unfortunately not preserved; but a conjectural restoration of Spy, No. 1, which is probably not far from the truth, gives an angle of -20°.

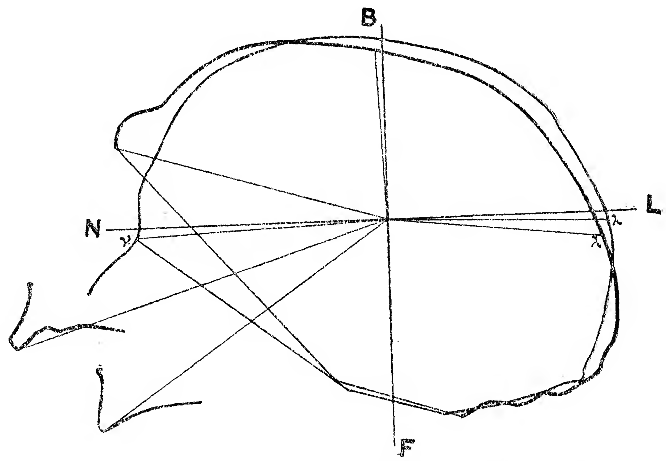

FIG. 1.—Sagittal profile of the skull of La Chapelle-aux-Saints (thick lines) and that of a Swede (thin lines) superposed on a common centre and the axis BF.

In this and the following figures the nasion is indicated by ν, the bregma by β, the lambda by λ ; the nasion pole by N, the bregma pole by B, the lambda pole by L, and the foraminal pole by F.

Broadly summed up this means that the periphery of the brain case measured from the axis of the occipital foramen to the nasion measures on an average three right angles in *H. sapiens,* while in *H. neandertalensis* it fails to do so by from 10° to 17°, or possibly 20° (fig. 1).

This is a purely morphological fact; its interpretation may be left for later discussion, but it may be pointed out here that the arbitrary choice of the foraminal axis as a basis of reference throws the whole burden of difference between different profiles on to the nasion. It is a simple matter, however, when comparing two superposed sections to rotate them on their common centre and thus change the basis to, say, the nasion radius. Then the whole burden is transferred to the foramen magnum and manifested there by a

shift forwards or backwards and a change in the obliquity of its major diameter (fig. 2).

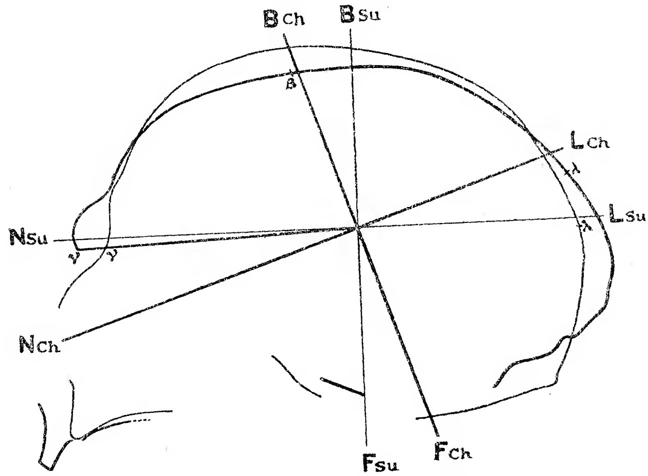

FIG. 2.—The same profiles superposed on a common centre, but on the nasion radius instead of the axis BF. Su, Swede ; Ch., La Chapelle-aux-Saints.

If we turn next to the anthropoid apes we find that the nasion angle of the adult has a still larger negative value, in the Gorilla $-39°$, in the Chimpanzee $-40°$, and in the Orang $-41°$.

In young forms of these apes it is much less but never becomes positive as in the human subject; thus in an 8 months human fœtus it is $+2°$, in a 1 year old child $+16°$, in a child of six $+7°$, while in the youngest example

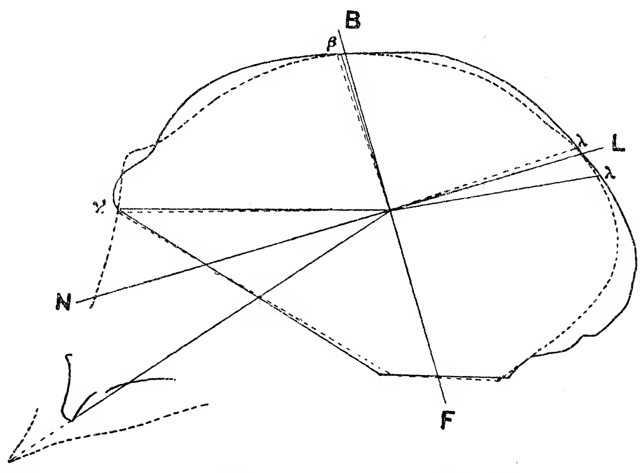

FIG. 3.—Sagittal profiles of La Chapelle-aux-Saints (continuous lines), and a young Chimpanzee (dotted lines), superposed on a common centre and the axis BF. The profile of the Chimpanzee is magnified for comparison.

I have examined of an Orang which had cut its first upper and lower incisors it is $-7°$, in one young Chimpanzee it is $-9°$, and in another older which has cut its second but not its third molar the angle is $-16°$.

Thus it would appear that a sharp distinction is established by this character between the higher apes and existing men at a very early stage of their career.

The sagittal section afforded by the Chimpanzee with a nasion angle of $-16°$ is shown enlarged and superposed on the corresponding section of La Chapelle-aux-Saints in fig. 3. A remarkable correspondence will be observed. The lambdas are not far apart, the bregmas differ by only 1° and the nasion angles are almost identical.

Observations on the Changes seen in Living Cells during Growth and Division.

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(From the Laboratories of the Cambridge Research Hospital.)

[Plates 2–5.]

The observations recorded in this paper were made on cultures *in vitro* of embryonic and adult chick tissues. The cultures chiefly studied were choroidal cells from the eyes of seven to nine days' chick embryos and cartilage cells from knee-joints of adult fowls.

The method of cultivation was embedding small fragments of tissue on a coverslip in one drop of chick plasma, to which was added one drop of embryo chick extract. The coverslip was inverted over a hollow glass slide, sealed with melted paraffin wax, and at once placed in an incubator at 39° C. The tissues were sub-cultured every second day. The cells observed were found in cultures which had been growing for 24 hours in the incubator after sub-culture.

The changes described were seen equally well in cultures from the embryonic choroid or from adult fowl cartilage, but in order to avoid any possible confusion, the description of the changes seen will be confined to cells from the embryonic choroid.

During observation, the microscope and cultures were kept at a temperature 39° C. in Nuttall's thermostat. The cells were watched over